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IS 6159 (1998): Recommended Practice for Design and Fabrication of Iron and Steel Products Prior to Galvanizing and Metal Spraying [MTD 24: Corrosion Protection]

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(दूसरा पुनरीक्षण)

Indian Standard

RECOMMENDED PRACTICE FOR DESIGN AND FABRICATION OF IRON AND STEEL PRODUCTS PRIOR TO GALVANIZING AND METAL SPRAYING

(Second Revision)

ICS 77.140.01; 77.060; 25.220.040

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

August 1998 **Price Group 6**

Metallic and Non-Metallic Finishes Sectional Committee, MTD 20

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Metallic and Non-Metallic Finishes Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1971 and was revised in 1985. The Committee felt the need for further revision in order to widen the scope of standard to provide guidelines to fabricators both in the field of hot dip galvanizing as well as sprayed metal coatings. So in this revision requirements for design and fabrication of metal articles prior to sprayed metal coatings have also been added. Further, additional details for design factors in the area of hot dip galvanizing have been provided in this revision.

Time and money are often wasted due to the faulty design of articles for the coating process to be applied. Finishing is only one part of the manufacturing process and should not be viewed in isolation while considering the overall costs and quality. The general principles described in this standard will assist in achieving the desired results for hot dip galvanized and sprayed coatings.

There is a great need to take the characteristics of the possible finishing processes into account at an early design stage and to regard finishing as an essential part of the production process rather than as an incidental necessity after production. A design that has considered essential features of the finishing process can effectively reduce the time and trouble and hence the cost of producing a good finish. Early consideration of the product requirements would help the designers to ensure that products can be satisfactorily finished with serviceable coatings without any compromise of other design objectives.

In the preparation of this standard assistance has been derived from the following publications:

a) Recommendations for the Design of Metals Articles that are to be Coated. Part 7— Sprayed Metal Coatings (BS 4479:1990), issued by the British Standards Institution.

b) Guidance document: Metal Coating for the Corrosion Protection of Iron and Steel in Structures ISO/TC 107/SC N 413, issued by the International Organization for Standardization.

Indian Standard

RECOMMENDED PRACTICE FOR DESIGN AND FABRICATION OF IRON AND STEEL PRODUCTS PRIOR TO GALVANIZING AND METAL SPRAYING

(*Second Revision*)

1 SCOPE

1.1 This standard describes the precautions in design and fabrication that should be taken to obtain good quality hot-dip galvanized coatings and metal sprayed coatings on iron and steel products.

1.2 Section A deals with recommendations for design of metal components prior to hot dip galvanizing and Section B deals with recommendations for the design of metal articles prior to sprayed metal coatings.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
1367 (Part 13) : 1983	Technical supply conditions for threaded steel fasteners: Part 13 Hot-dip galvanized coatings on threaded fasteners (*second revision*)
1387 :1993	General requirements for supply of metallurgical materials
4683:1968	Chilled iron shots and grits for use in foundries
5905:1989	Sprayed aluminium and zinc coatings on iron and steel
6586:1989	Recommended practice for metal spraying for protection of iron and steel

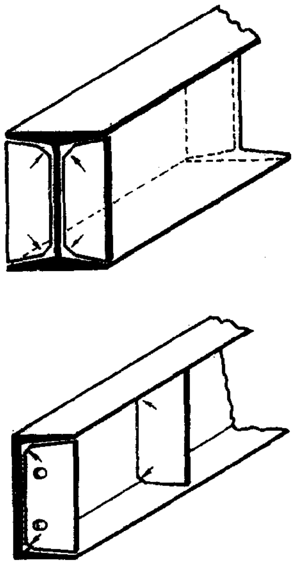
SECTION A

Recommendations for Design of Articles to be Coated by Hot Dip Galvanizing

3 PRECAUTIONS

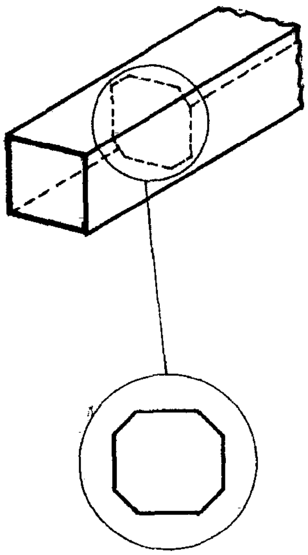
3.1 Access and Drainage of Molten Zinc

For complete protection molten zinc should be able to flow freely to all parts of the surfaces of the item to be galvanized. Accessibility to molten zinc requires means for the access and drainage of molten metal, and means for the escape of gases and sullage from internal compartments and pockets (venting). Some typical examples for the design details for venting and draining are illustrated in Fig. 1 to 14.



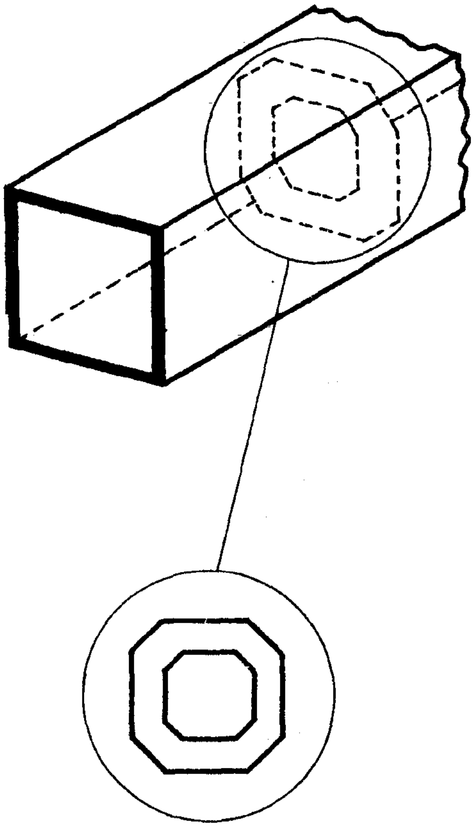
External stiffeners should
have the corners cropped
to eliminate 'dead pockets'

FIG. 1



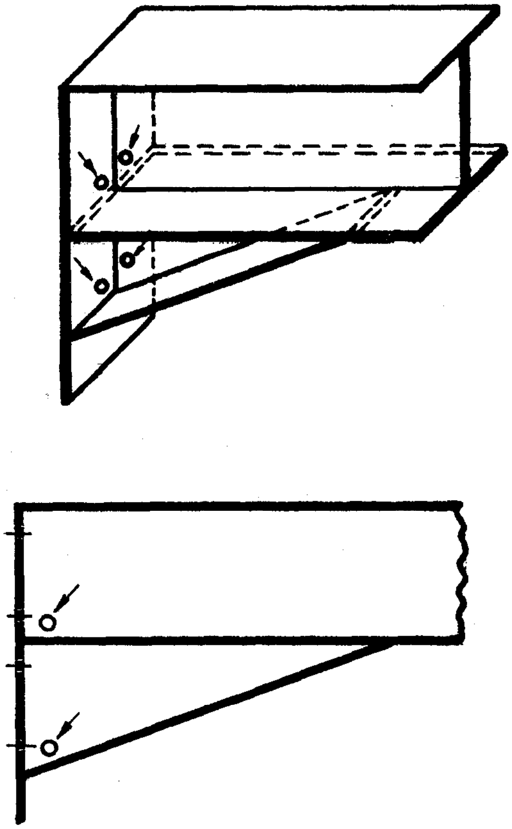
Internal diaphragms on
small box sections must
have large 'crops' in
the corners

FIG. 2



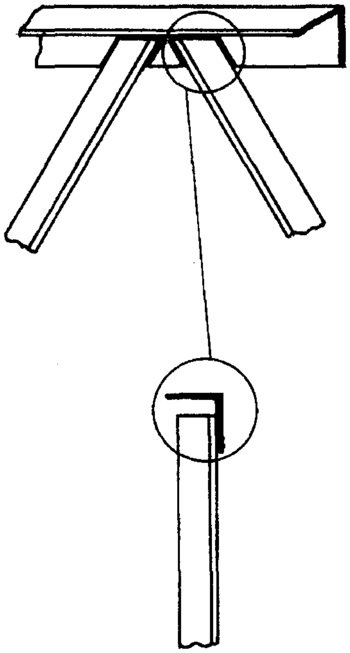
Internal diaphragms on large
box sections to have cropped
corners and 'manhole'.

FIG. 3



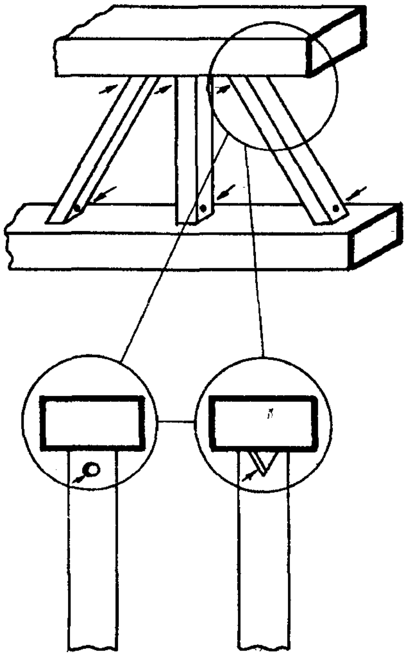
If holes can be provided
in the locations indicated
a cleaner blemish-free
coating will be obtained

FIG. 4



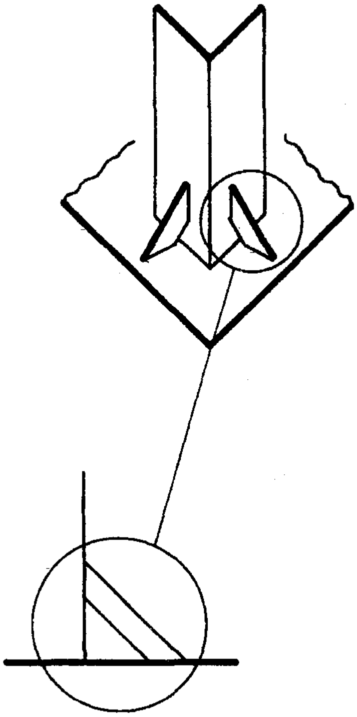
Angle bracing should, if possible, be stopped short of the main boom flange.

FIG. 5



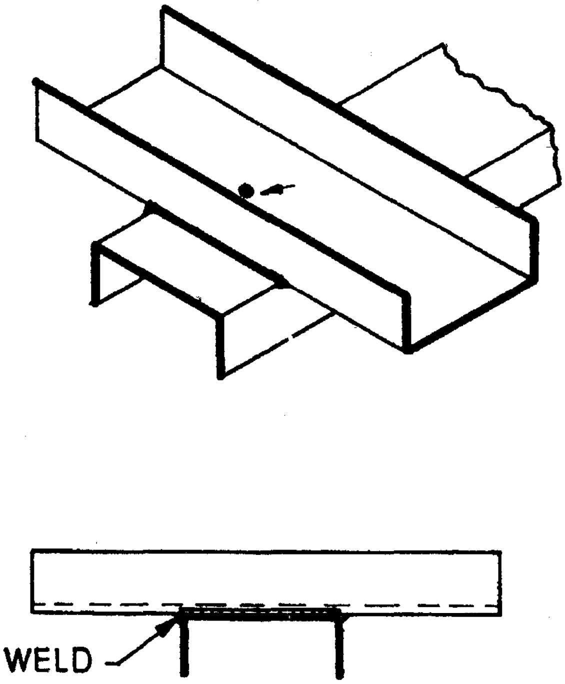
Structural hollow sections. Provision must be made for venting and draining. On vertical members, drilled holes should be provided diagonally opposite each other at top and bottom. Alternatively, a 'V' notch can be cut at the end of the member.

FIG. 6



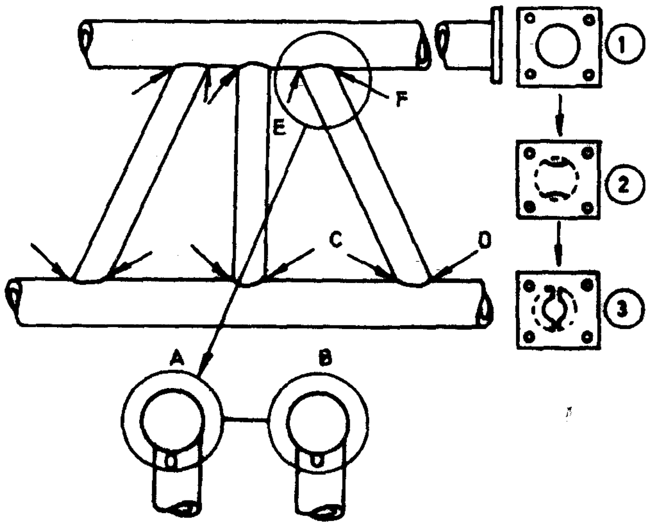
External stiffeners for beams and channels should have the corners cropped.

FIG. 7



If contacting surfaces cannot be avoided, as with these channels then the edges of the contacting areas should be continuously welded and a hole drilled through both members to eliminate the danger of an explosion in the galvanizing bath. If this is not possible then welding should be intermittent.

FIG. 8



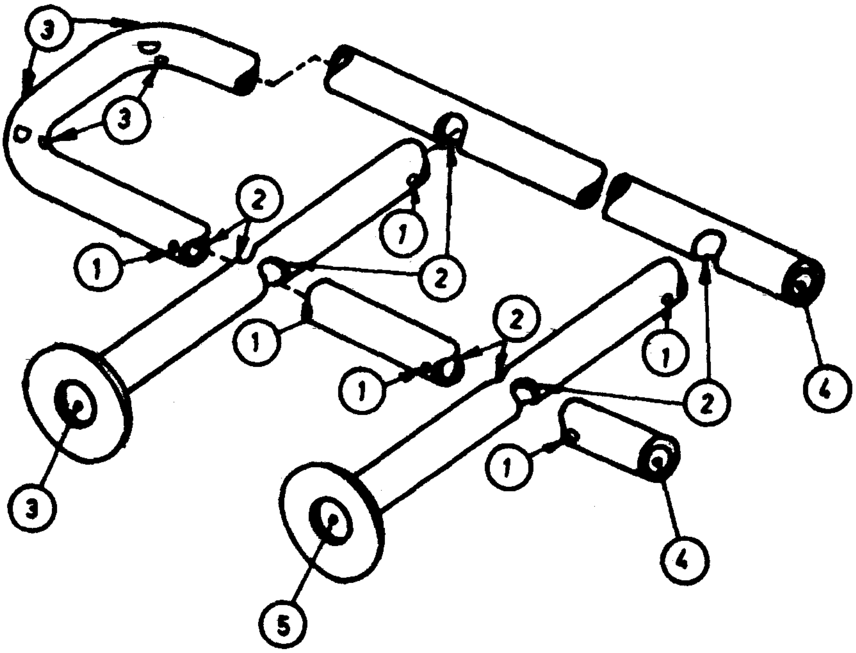
Hole location for vertical and angled sections shall be as shown in examples *A* and *B* by arrows on the drawing.

Each vertical and angled section shall have two holes at the top and bottom, 180° apart in line with horizontal members as indicated by arrows. Size of holes should preferably be equal and the combined area of the two holes at either end of the vertical and angled sections (that is, area *C* and *D*, or area *E* and *F*) should be at least 30 percent of the cross-sectional area.

End Plates Horizontal :

1	Most desirable — completely open 'same diameter'.
2 and 3	Equal substitutes — Openings as shown should be 30 percent of the areas of the inside diameter.

FIG. 9 PIPE TRUSS 76 mm AND LARGER

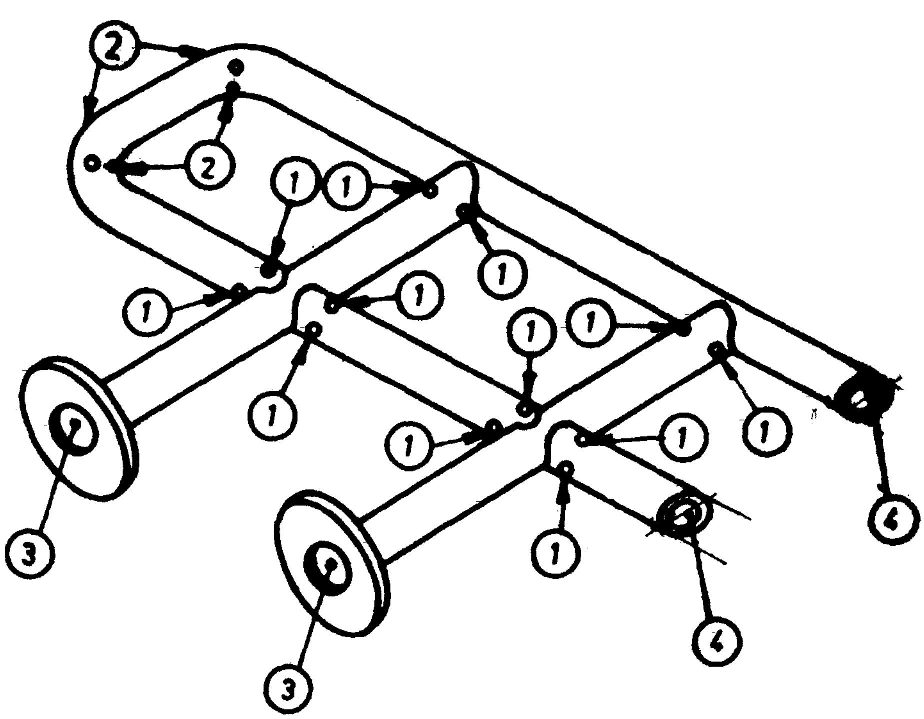


The above drawing illustrates desirable design features for fabrication of handrail that requires galvanizing.

1	Vent holes shall be as close to the weld as possible and not less than 9.5 mm in diameter.
2	Internal holes shall be the full inside diameter of the pipe for best galvanizing quality and lowest galvanizing cost.
3	Vent holes in end sections or similar section shall be a minimum 12.7 mm in diameter.
4 and 5	Any device used for erection in the field that prevents full openings on ends of horizontal rails and vertical legs shall be attached after galvanizing.

Vent holes shall be visible on the outside of any pipe assembly.

FIG. 10 HANDRAIL



The above drawing illustrates an acceptable alternative if full internal holes (the full inside diameter of the pipe) are not incorporated in the design of the handrail.

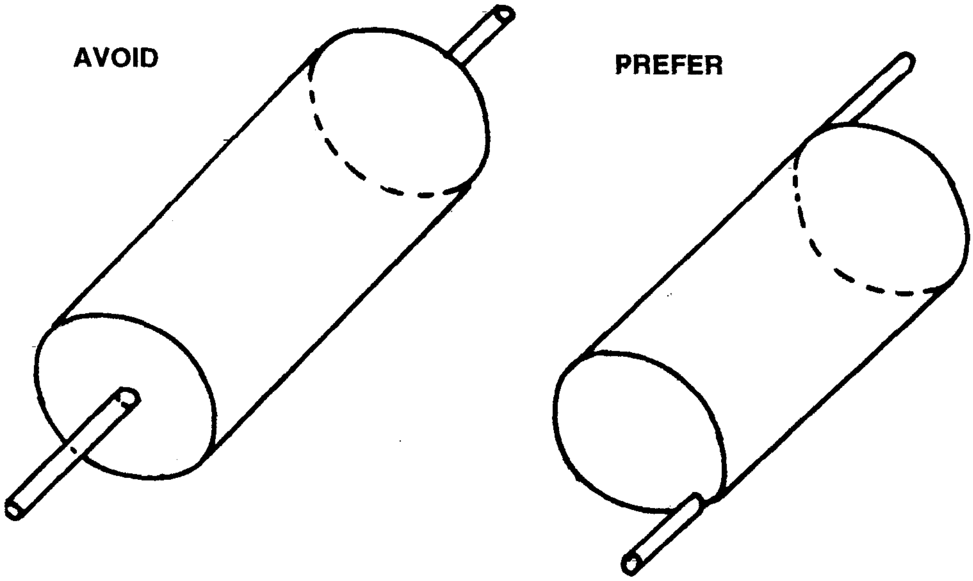
1 Each vent hole shall be as close to the weld as possible, must be 25 percent of the inside diameter of the pipe, but not less than 9.5 mm in diameter. The two holes at each end and at each intersection shall be 180° apart and in the proper location as shown.

2 Vent holes in end sections or in similar sections shall be at least 12.7 mm in diameter.

3 and 4 Any device used for erection in the field that prevents full openings on ends of horizontal rails and vertical legs shall be attached after galvanizing.

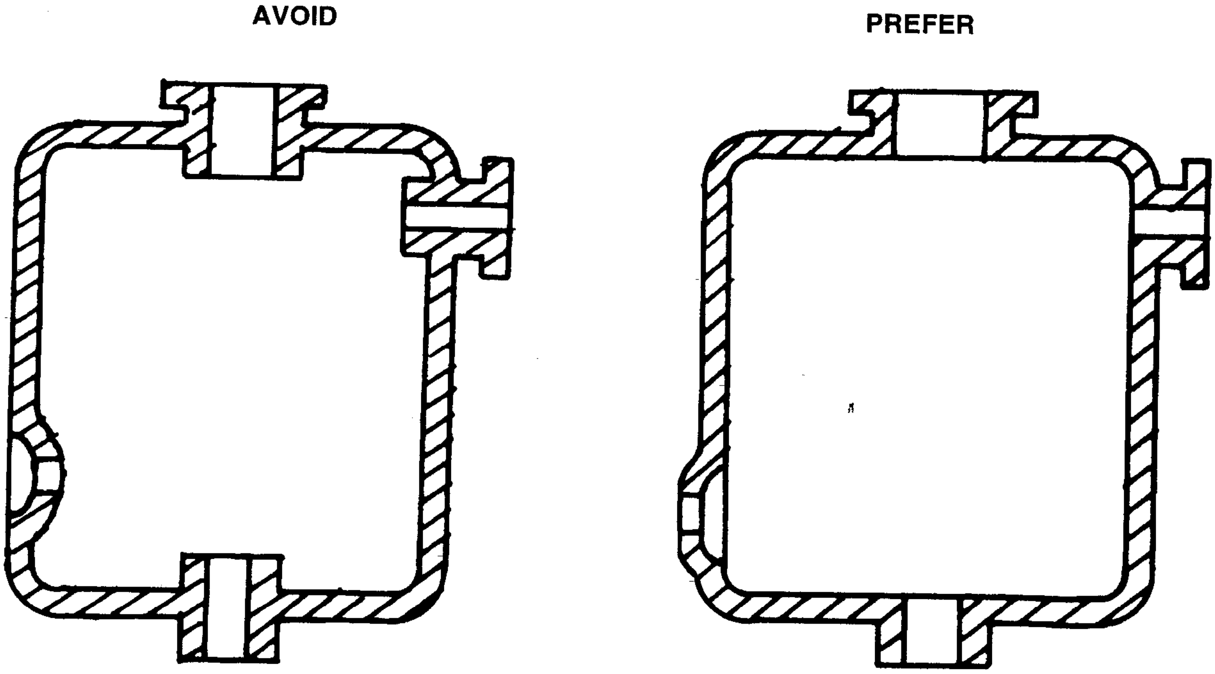
Vent holes shall be visible on the outside of any pipe assembly.

FIG. 11 HANDRAIL-ALTERNATIVE



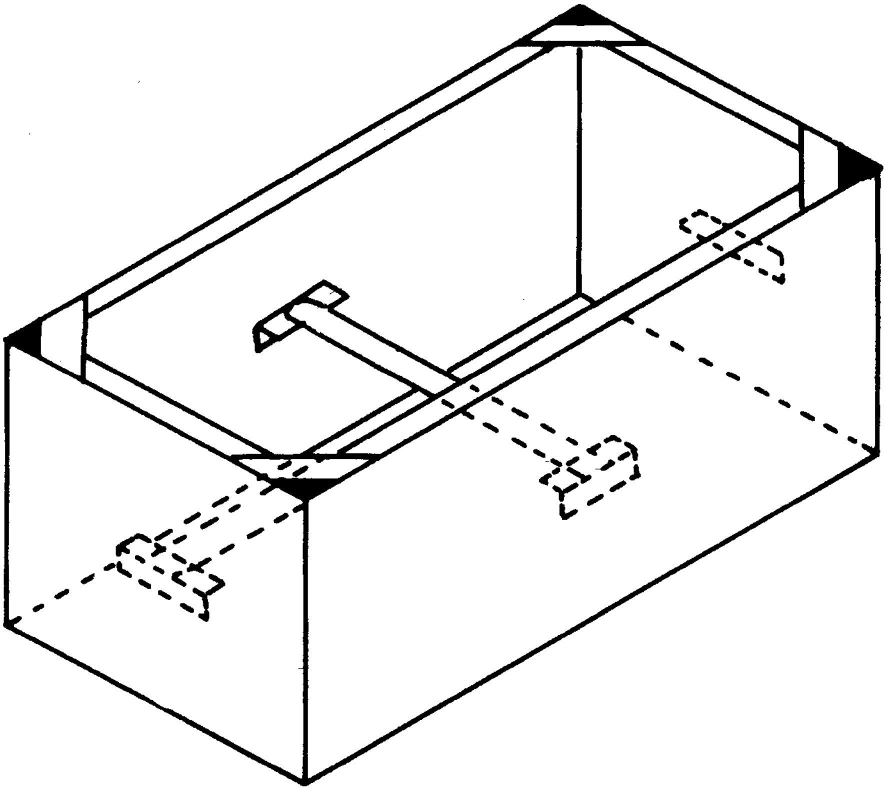
Pipe connections to hollow vessels should be arranged to assist venting and draining.

FIG. 12 HOLLOW VESSELS



Internal bosses should be avoided wherever possible, if not an extra tapped hole should be included in the fabrication and this may be plugged after hot dipping.

FIG. 13 ENCLOSED CAVITIES



Large open top tanks should be braced to minimize distortion. Where angles are used on the rim of the tank, apertures should be provided in the corners.

FIG. 14 OPEN TANKS

3.2 Overlapping or Contacting Surfaces

Wherever contacting surfaces cannot be avoided they should be completely sealed by welding. This will prevent the rusting of surfaces not amenable to galvanizing. The welds themselves should be free of pinholes.

3.3 Steel Sheet in Contact with Other Surfaces

All oil, grease, paint or lacquer should be removed from contacting surfaces before assembly. Grease or oil become volatile at galvanizing temperature and will generate gas which will prevent the zinc from sealing the contact edges. All steel should be degreased before pickling and in the case of folded assemblies before folding and assembling.

3.4 Welding

All recognized welding procedures may be used provided it is ensured that the welding slag is removed before pickling by suitable mechanical means.

3.5 Enclosed Sections

Tube assemblies and sealed cavities such as tanks require adequate venting and drainage holes. The galvanizer should be consulted about the size and location of these holes.

3.6 Pipe Assemblies

On welded pipe assemblies, full open mitre joints should always be used. Under no circumstances should a blind section be included in any pipe assembly (*see* **2.8**). Steel floor flanges instead of cast iron floor flanges should be used in pipe railings.

3.7 Labels and Markings

Permanent identification mark should be deeply punched or embossed in a 'standard' position on each of the members. An effective method is to put the identification on weld metal, which may be done, in some cases, using dots of weld metal as a code to reduce the number of letters and figures required. Alternatively, the identification can be punched on a light metal tag which can be welded to the structure at a suitable location.

3.7.1 Temporary identification marks for use during fabrication should be made with a material, which is removed during acid pickling.

3.8 Assemblies of Different Materials

3.8.1 If a uniform galvanized finish is required, combinations of cast iron, cast steel, malleable iron and steels of different analysis or surface condition should not be used in the same assembly. If cast materials are included in the assembly, they may require to be shot- or sand-blasted before pickling.

3.8.2 If any surfaces of a part are machined or if any members of an assembly are excessively rusted, the entire assembly should be sand- or shot-blasted or wire brushed.

3.9 Size and Shape

Before design and fabrication, the dimensional limitations on size and shape imposed by the galvanizing facilities should be determined. Objects larger than the length of the galvanizing bath may be galvanized by 'double dipping', that is, immersing part of the fabrication and then reversing it either for length or depth to galvanize the part which was left uncoated on the first dip.

3.10 Blast-Cleaning Hot-Rolled Parts

Heavy scale present on the non-machined surface will require longer pickling time during which the machined surface will be damaged by over-pickling. Therefore, whenever any surfaces on a hot-rolled part are machined, the entire pieces should be blasted clean prior to machining.

3.11 Movable Parts

The design should provide sufficient clearance to permit free movement of movable parts after galvanizing. Generally a clearance of 0.8 mm is sufficient.

3.12 Threads

To maintain free fit, oversize tapping of nuts and tapped holes is required when the bolt or male thread is hot-dip galvanized. In this regard, allowance on diameter for female threads as recommended in IS 1367 (Part 13) shall be followed.

3.13 Castings

The quality of galvanized coatings on coatings depends largely on the design, surface finish and preparation for galvanizing. The following practices are recommended.

a) Use large fillet radii;

b) Use large pattern members;

c) If any machining is done on a portion of the casting, the entire casting should be thoroughly sand- or shot-blasted if a uniform finish is required;

d) Internal threading should be done after galvanizing in case of through holes and threading shall be done after galvanizing in case of blind holes; and

e) Malleable and Grey iron castings should be heat-treated to prevent embrittlement during galvanizing. Following heat treatment and prior to galvanizing, castings should be sand- or shot-blasted.

SECTION B
Recommendations for Design of Metal Articles to be Coated by Spraying

4 DESIGN OF ARTICLES

4.1 General

Sprayed metal coatings are produced industrially by melting the coating metal and projecting it in the form of a dispersed spray onto the surface to be coated. Metal spraying is normally a 'cold' process and the heat input to the material being sprayed may be kept low. The greatest volume of protective metal spraying is done with aluminium or zinc on iron or steel. Other materials can be deposited, ranging from tin and tin alloys, copper and copper alloys, steels and stainless steels, to nickel alloys (and some ceramics). The corrosion resistance of metal sprayed coatings may be enhanced by the application of specially formulated sealers. These sealers not only extend the useful life of the coating but provide a smoother finish and give colour as desired. The multilayer conventional paint systems are generally less advocated. Expert guidance from the processor should be obtained at the design stage.

4.2 Process

Metal spraying for protection involves two distinct stages, namely, surface preparation and metal spraying.

4.2.1 *Surface Preparation*

Surface preparation by grit blasting is the most commonly applied method, using chilled iron grit to IS 4683. The surfaces to be coated should be completely free from loose particles and dust.

4.2.2 *Metal Spraying*

Metal spraying is effected by manual means or automatic equipment, and both control and inspection of sprayed metal coatings have been covered in IS 5905.

4.2.3 *Design Consideration*

The efficiency and economy of satisfactory surface preparation, as well as subsequent metal spraying, are influenced by the design considerations described below:

a) Components and structures to be metal sprayed should be designed from the outset with metal spraying clearly in mind. Failure to do so is almost certain to increase the difficulties and costs of application, and also to reduce the overall service life.

b) The important guidelines given below should be observed:

   i) The design should ensure that all surfaces are fully accessible for surface preparation, for the subsequent removal of grit, and to permit complete and uniform application of the sprayed coatings.

   ii) Structures should be designed so that corrosion has the greatest difficulty in establishing and may be focal point from which it can spread. As major corrosive factors are moisture and dirt in which marine and industrial corrosive agents can collect and concentrate, this factor demands cleanness of design and the elimination of all features that might facilitate lodging or retention of moisture and dirt.

   iii) The overall design should be planned to facilitate full inspection, ease of cleaning, and maintenance.

4.3 Design Features

4.3.1 The increased use of welded construction, and the general simplification of design that has resulted, have made the following design recommendations easier to meet. Good design for welding has much in common with good design for protection since, in general, design features that are difficult to weld are also difficult to protect by metal spraying.

4.3.2 Figures 15 to 22 illustrating preferred/ deprecated design features for articles to be sprayed metal coated are given in Annex A.

4.3.3 Many of the design recommendations given in (a) to (j) are equally applicable to any engineering structure exposed to corrosive attack, irrespective of the precise method of protection proposed and, in such cases, reference should also be made to IS 6586.

a) Any design features that introduce, 'shadowing', that is, the prevention of easy access for grit-blasting or for metal spraying to relevant surface areas, are highly undesirable and should be avoided.

b) Since in both grit-blasting and metal spraying the materials are projected essentially in straight lines, the design should facilitate an approach at 90° to the surface being treated. The approach angle should never be less than 45° to the surface.

c) As both the grit-blasting nozzle with its attached high pressure, relatively inflexible air hose and the metal spraying pistol with its attachments operate at nozzle distances of between 150 mm and 200 mm, there should be at least 300 mm access length in front of any surface to be treated.

d) Narrow gaps, blind crevices, deep pockets and acute interior angles should be avoided as these features liable to prevent uniform surface preparation and coating application are likely causes of locally impaired corrosion resistance. Similarly, small section 'E' or 'T' stiffeners and deep, narrow, channel sections are likely to create 'blind' areas that can be neither adequately prepared nor sprayed. Their use should, therefore, be avoided and 'flats' or 'bulk-flats' stiffeners adopted instead.

e) Enclosed spaces, for example, tanks, should have adequate manholes to give the operators full access to all internal surfaces. A second outlet should also be provided through which essential positive ventilation can be arranged. Grit-blasting creates a considerable volume of dust, which has to be quickly and positively removed in the interest of clean surface finish and operating visibility. Metal spraying in a confined space also generates metal dust fumes and heat, and the maintenance or reasonable working conditions required very good ventilation, in addition to an independent air supply to the operator's protective helmet.

f) If conventional blasting methods are used for the internal surface preparation of tanks or other internal spaces, provision should be made for the removal of heavy grit accumulations.The availability of adequate access manholes and ventilation outlets can considerably simplify grit removal, with the use of heavy duty vacuum cleaners. Alternatively, the use of blasting equipment employing closed-circuit vacuum recovery of spent grit prevents any heavy grit accumulations from arising. Further, the constant cleaning of the grit minimizes the dust problem. This equipment also considerably simplifies final removal of grit residues and dust which, if left, can provide centres for the initiation of corrosion.

g) Baffles and fittings inside tanks and enclosed spaces should be made removable to facilitate processing. If this is not possible, special attention should be given an access to all surfaces of such fittings.

h) For the satisfactory preparation and metal spraying of internal surfaces of hollow and tubular members, the limitations imposed by access' and 'nozzle distance' requirements should be considered. Generally, short straight sections greater than 100 mm diameter can be metal sprayed by the use of special attachments to the blasting and spraying equipment. Bent tubes and small hollow sections below 100 mm diameter are, however, exceedingly difficult to process satisfactorily, and their use should be avoided unless agreed mutually.

j) For components and structures subjected in service to thermal shock, rapid expansion and contraction, or heavy vibration it is important that the design should reduce expansion and contraction to a minimum and should incorporate fully adequate stiffening of the sprayed metal surfaces.

4.4 Corrosion-Initiating Centres

4.4.1 Crevices and narrow gaps which arise when back-to-back angles are used, or where stiffeners are welded on by short intermittent fillet welds on alternate sides, should be avoided as they are difficult to protect. Continuous welds should be preferred.

4.4.2 Butt joints should be used in preference to lap joints unless the later are sealed off by continuous smooth welds.

4.4.3 Corners should preferably be rounded since they are easier to protect than those that are square. They also simplify inspection, cleaning and maintenance, and minimize dirt and moisture retention.

4.4.4 Rounded edges are desirable in order to provide greater surface area to take the protective coating uniformly and to overcome the difficulty of attaining adequate coating thickness or sharp edges. Coatings on sharp edges are also more susceptible to damage.

NOTE — Where there are large 'edge' areas (for example, on expanded metal) subject to atmospheric corrosion, it is generally considered preferable to use zinc coating rather than aluminium because zinc gives better cathodic protection to steel.

4.4.5 Blind crevices, narrow gaps, lap joints, pockets, chemicals and horizontal flat surfaces are potential points for corrosion attack arising from retention of moisture and dirt including the grit used in surface preparation.Wherever possible, design provision should be made for evaporation, run-off or drainage of moisture either by presetting or provision of well-placed and adequate drainage holes (*see* Fig. 7).

4.4.6 Wetting surfaces to be joined by welding should be totally sealed by beads of welding to prevent entrapment of blasting grit and to prevent the ingress of moisture to untreated areas.

ANNEX A

(*Clause* 4.3.2)

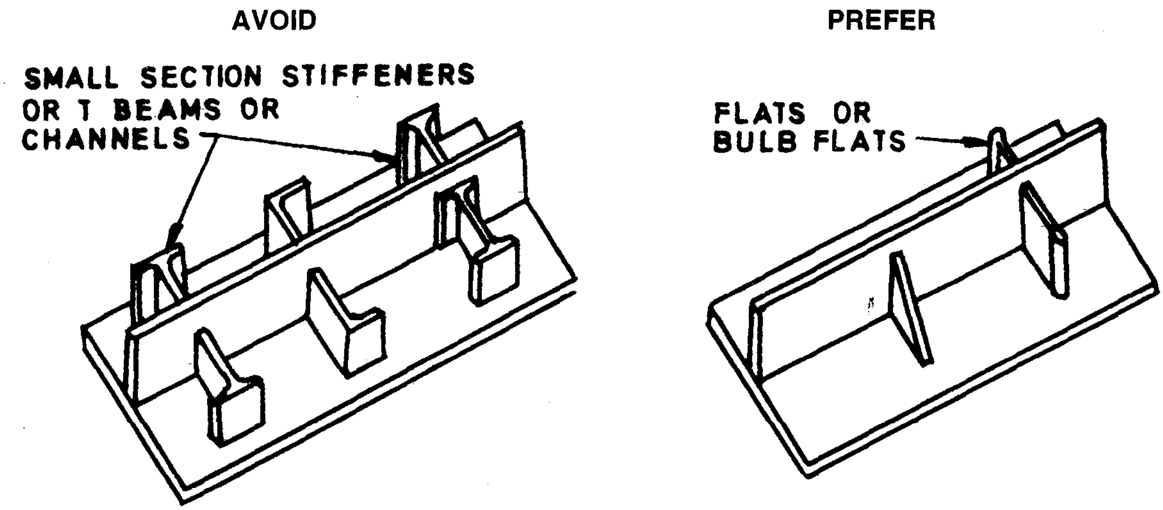


FIG. 15 ACUTE INTERIOR ANGLE

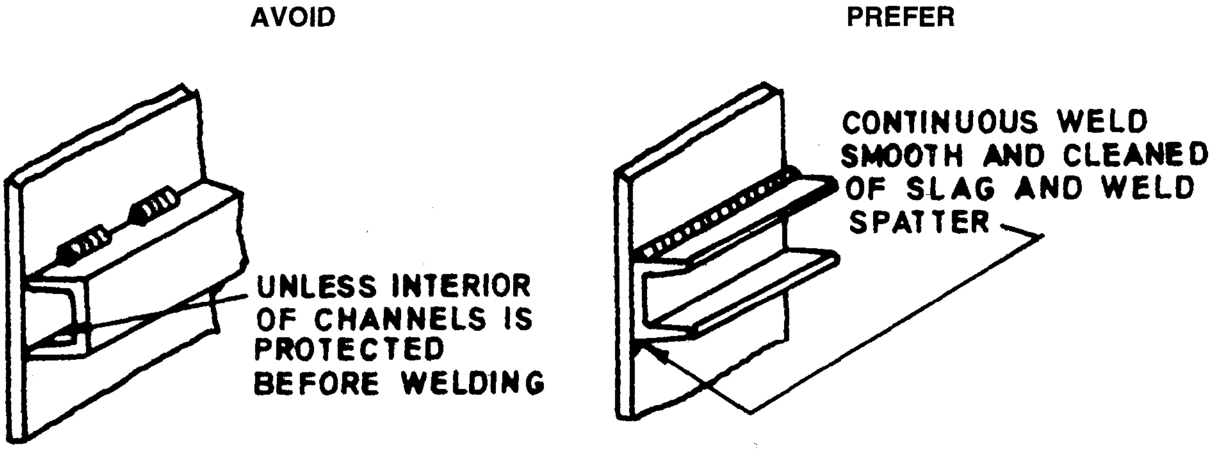


FIG. 16 BLIND CREVICES

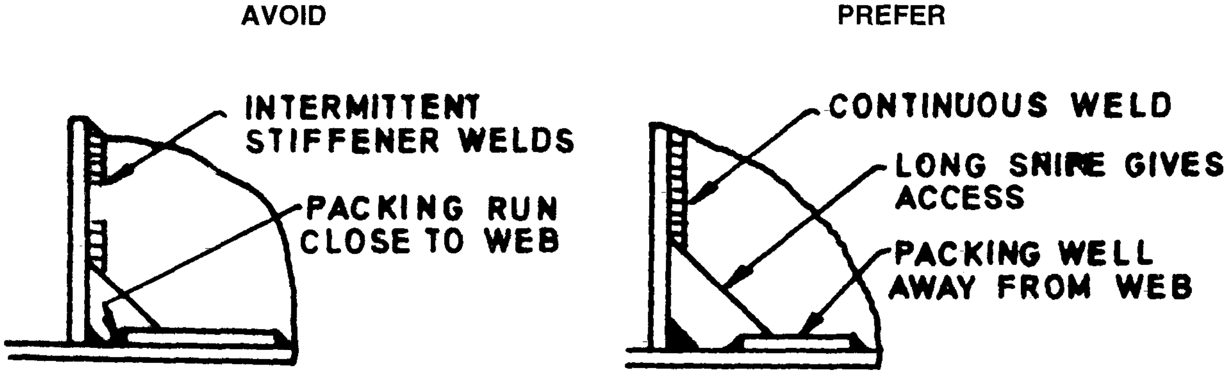


FIG. 17 NARROW GAPS

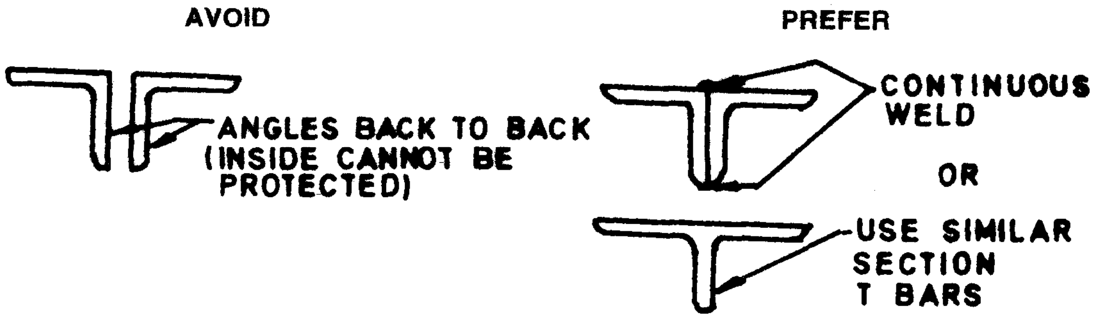

AVOID
PREFER
ANGLES BACK TO BACK (INSIDE CANNOT BE PROTECTED)
CONTINUOUS WELD
OR
USE SIMILAR SECTION T BARS

FIG. 18 CREVICES

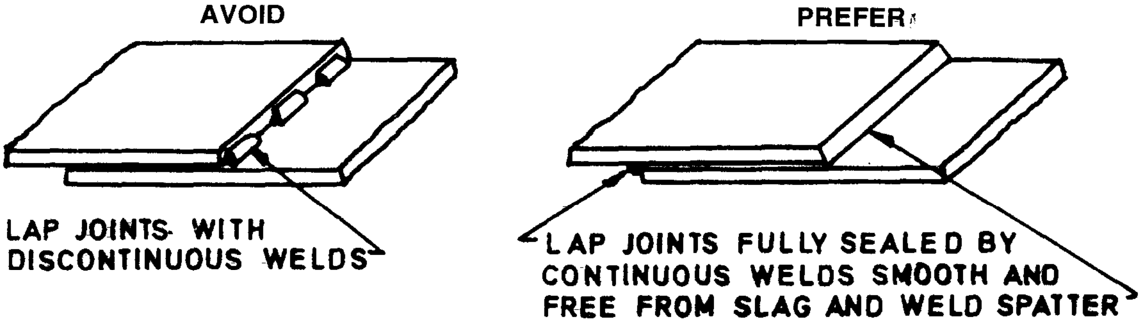

AVOID
PREFER
LAP JOINTS WITH DISCONTINUOUS WELDS
LAP JOINTS FULLY SEALED BY CONTINUOUS WELDS SMOOTH AND FREE FROM SLAG AND WELD SPATTER

FIG. 19 LAP JOINTS

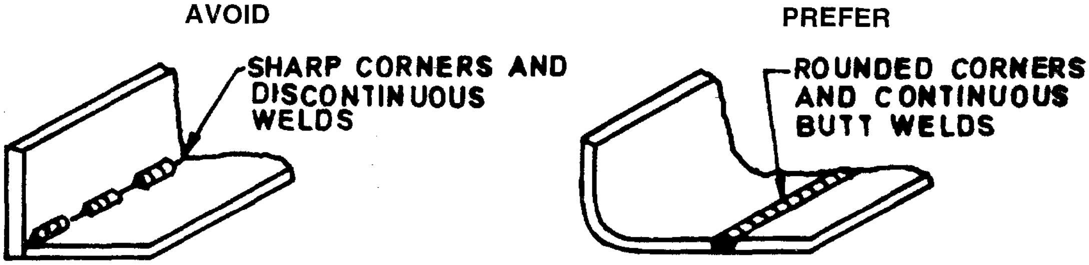

AVOID
PREFER
SHARP CORNERS AND DISCONTINUOUS WELDS
ROUNDED CORNERS AND CONTINUOUS BUTT WELDS

FIG. 20 CORNERS

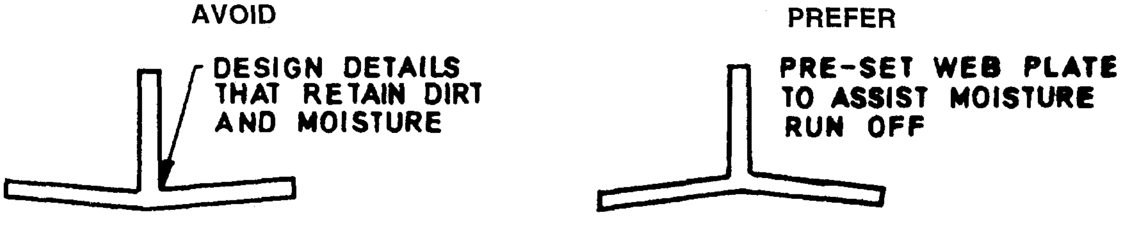

AVOID
PREFER
DESIGN DETAILS THAT RETAIN DIRT AND MOISTURE
PRE-SET WEB PLATE TO ASSIST MOISTURE RUN OFF

FIG. 21 FLAT SURFACES

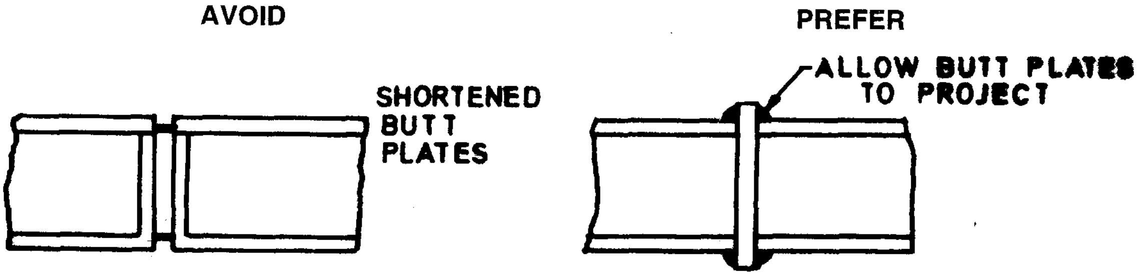


FIG. 22 POCKETS

Bureau of Indian Standards

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